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ABSTRACT

Competence in mathematics has long been identified as a critical skill directly related to educational and occupational choices. Mathematical skills are important for admission to many college majors, for a number of professional occupations, and increasingly for computerized technical occupations. Yet compared to male students, fewer female students elect to take mathematics beyond the minimal requirement. While females may receive less encouragement from parents and teachers, it is not the case that they are being systematically excluded through discriminatory course availability. On the contrary, all too frequently females choose not to take more advanced mathematics courses. While many researchers have expressed interest in this problem, especially in the effects of attitudes on achievement and course selection in mathematics, research has been seriously limited by a number of methodological and conceptual shortcomings. Of major importance is the lack of an integrative theoretical framework to guide the selection of a comprehensive set of variables for study and a definition of these variables in terms of their relevant dimensions. In response to this shortcoming, this paper summarizes research on achievement and course selection in mathematics and then integrates this research into a theoretical model for studying students' academic choices and decisions.
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A Theoretical Framework for Studying Students' Course Selection in Mathematics

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Competence in mathematics has long been identified as a critical skill directly related to educational and occupational choices. Mathematical skills are important for admission to many college majors, for a number of professional occupations and increasingly for computerized technical occupations. Yet compared to male students, fewer female students elect to take mathematics beyond the minimal requirement. While females may receive less encouragement from parents and teachers, it is not the case that they are being systematically excluded through discriminatory course availability. On the contrary, all too frequently females choose not to take more advanced mathematics courses (Sherman & Pennema, 1977; Pennema, Note 1; Fox & Brody, Note 2; Sells, Note 3).

While many researchers have expressed an interest in this problem, especially in the effects of attitudes on achievement and course selection in math, their research has been seriously limited by a number of methodological and conceptual shortcomings. Of major importance is the lack of an integrative theoretical framework to guide the selection of a comprehensive set of variables for study and a definition of these variables in terms of their relevant dimensions. In response to this shortcoming, this paper first briefly summarizes past research on achievement and course selection in mathematics and then integrates this research into a theoretical model for studying students' academic choices and decisions.

Overview of Past Research

Biological factors. A longstanding explanation attributes sex differences in mathematics learning and course selection to "true" ability or aptitude differences. Basing their argument on the premise that spatial skills are an important factor in mathematics learning, several researchers have shown that men and women differ in their ability to perform spatial problem solving tasks (cf. Maccoby & Jacklin, 1974; Wittig & Pedersen, 1979).

Recently, this position has been judged to have limited significance in explaining sex differences in math achievement and course selection. First, there is some evidence suggesting that early learning experiences, rather than biological factors alone, may play an important causal role (Connors & Serbin, 1978). Second, to the extent that spatial abilities are linked to mathematics learning and that males and females inherently differ in these abilities, then these differences should be reflected in their early mathematics achievement. However, until the age of twelve or thirteen, girls do just as well as boys, if not better, on tests of quantitative skills (Penner, 1974). It is not until the adolescent years that boys begin to outperform girls. By this time other factors such as interest or enjoyment may intervene and affect students math achievement.

Socialization Experiences. The differential socialization experiences of boys and girls have also been proposed as an explanation for sex differences in math achievement and course selection. Research on math achievement has suggested three important ways in which

significant socializers may potentially contribute to the observed sex differences. First, the underrepresentation of appropriate female role models in math could be accounting, in part, for the disproportionate numbers of males and females enrolled in math courses. Second, because mathematics is one area of achievement commonly viewed as "masculine" in our culture, socializers may have different expectations and goals for boys and girls which are conveyed through a variety of direct and indirect means. In support of this, one study of elementary and high school teachers, for instance, reported that 41% of the teachers surveyed felt that boys do better in mathematics than do girls, while none believed that girls outperform boys (Ernest, 1976). Other studies have documented that females are typically not encouraged by parents and counselors to pursue careers in math-related fields such as business, engineering, mathematics, or science (Casserly, Note 5; Haven, 1972; Luchin, Note 4). A final way in which socializers may affect mathematics achievement is by providing or encouraging different activities for their children such as competitive sports or recreational games that train differing skills and interests.

Each of the processes alone could produce differences in the academic choices boys and girls make. Acting in conjunction with one another, they can exert a powerful influence. But the causal significance of these differential socialization experiences on student's attitudes and achievement behaviors has rarely been studied, even though research on student's attitudes towards mathematics suggests that this may be an informative line of research to pursue.

Students' attitudes towards mathematics. Based on the premise that attitudes and values are the primary motivating force behind behavior,

student's attitudes towards mathematics has been proposed as another major source of sex differences in mathematics achievement and course selection. Consistent with widely held cultural views, several studies show that high school students sex-type mathematics as a male achievement domain (Ernest, 1976; Pennema & Sherman, 1972; Fox, 1975; Stein & Smithells, 1960; Armstrong & Kahl, Note 6). This sex-typing of mathematics appears to be reflected in other attitudes that students hold towards mathematics:

Girls perceive mathematics to be less useful for their future goals and report less interest in the subject matter than boys do (Fox, 1975; Haven, 1971; Hilton & Berglund, 1971; Sherman & Pennema, 1977).

Girls perceive themselves as having less math ability and report less confidence in learning mathematics than boys do (Ernest, 1976; Pennema & Sherman, 1977; Fox, 1975; Sherman & Pennema, 1977; Stein & Smithells, 1960; Tobias, 1978; Armstrong & Kahl, Note 6).

Girls report math to be more anxiety provoking and that they are more likely to avoid taking mathematics when given the option than boys do, perhaps because of its potential conflict with their sex-role identity (Ernest, 1976; Pennema & Sherman, 1977; Fox, Tobin & Brody, 1979; Robitaille, 1978; Fox & Brody, Note 2).

Although sex differences in several attitudinal variables have been uncovered, their causal origins and effects have not been adequately addressed. The few studies that have examined this latter issue suggest that both self-perceptions of math ability and the perceived usefulness of math for future goals play an important role in determining students' academic choices in mathematics.

In summary, each of these bodies of research have provided insights into the mechanisms contributing to students math achievement and course selection behaviors. But because researchers have approached this area

of study from a variety of theoretical perspectives and consequently, have focused their research on a subset of possible causes, there is no overriding theme linking together these disconnected findings. A theoretical framework that integrates these components would provide a more complete picture of students' academic choices. Given the socio-cultural context in which mathematics learning takes place, such a framework should be comprehensive in its approach to a phenomenon that is undoubtedly influenced by a complex interplay of many of the factors reviewed earlier. It should also take into account the interrelationships among the various components, the origins of individual differences and the causal links between these components and subsequent academic choices. Our theoretical framework was designed with these concerns in mind.

Overview of Theoretical Model

The theoretical model underlying this research project builds upon the expectancy/value models of achievement behaviors advanced by Atkinson (1974), Crandall (1969), and Weiner (1974). As figure 1 shows, we propose that students' decisions to continue taking mathematics are a joint function of students' a) expectations for their performance in a particular math course and, b) perceptions of the importance or incentive value of taking mathematics. Figure 1 also shows that these variables are, in turn, assumed to be influenced by students' goals and their concepts of both their own math ability and the task demands. Individual differences on these attitudinal variables are further assumed to result from students' perceptions of the beliefs of major socializers, the students' interpretation of their past history of math

performance, and the students' perception of appropriate behaviors and goals.

Returning to the major components of our model, expectancy and value, I would like to discuss in a little more detail the mediators just described and their proposed relation to students' expectancies, values, and academic choices. Following this, I would like to briefly outline the utility of this conceptualization for explaining the origins of individual differences in general achievement behaviors, with particular attention given to sex differences in course selection in mathematics.

Expectancies

By adolescence students' achievement expectations are clearly related to their general achievement performances. In the case of math achievement, studies using measures of confidence in learning mathematics, a conceptually related variable, have reported a similar link (Sherman & Fennema, 1977; Armstrong & Kahl, Note 6). Not surprisingly, these studies show that students are more likely to enroll in advanced mathematics courses when they are confident of their math performance.

Given that achievement expectancies have been demonstrated to play an important role in students' academic choices, we have identified a number of factors shaping these expectancies. Within our model, we propose that expectancies are most directly influenced by self-concepts of ability and estimates of the task difficulty. These variables as well as expectancies are all, in turn, shaped by a variety of historical events and social factors.

It is important to note that our model assumes that the effects of students' achievement histories or socialization experiences are mediated by their interpretation of those events rather than determined by the events themselves. For example, doing well in math is presumed to influence one's expectancies to the extent that doing well is attributed to one's ability. Past research has shown that girls do as well in math as boys throughout their formative years, yet they do not expect to do as well nor are they as likely to go on in math. The extent to which boys and girls differ in their interpretation of outcomes because of the differential information they receive from their social environment relevant to these expectancies could, in part, account for this apparent paradox. For example, since the female sex-role stereotype implies low competency in many areas of achievement, but particularly in mathematics, the integration of this belief into girls' self-concepts may lead them to accept the stereoytype as a valid description of "true" ability differences. This could, in turn, differentially influence males' and females' interpretations of their math performances and consequently, their perceptions of themselves as math learners and their math achievement expectancies. Therefore, a student's causal attribution for success and failure in math, socializers expressed attitudes and expectancies for the student, and a student's perception of socializers' behaviors are all of special interest to our study.

Task Value

As discussed earlier, research on math achievement has identified students' perceptions of the usefulness of math as an important determinant of students' enrollment decisions. Building upon this

research and the work of other achievement theorists, our model proposes that the value or importance of engaging in a specific achievement task is determined both by the characteristics of the task and by the needs, goals and values of the person. The degree to which the task is able to fulfill needs, to facilitate reaching goals or to affirm personal values determines the value a person attaches to engaging in that task.

The broader domain of value can be divided into three components: attainment value, intrinsic value or interest and utility value. Attainment value can be defined as the importance of doing well in a task. In its broader form, this component can include a variety of dimensions, including perceptions of the task's ability to confirm salient and valued characteristics of the self (e.g., masculinity, femininity, competence), to provide a challenge, and to offer a forum for fulfilling achievement, power and social needs. We assume that the perceived qualities of the task interact with an individual's needs and self-perceptions in determining a task's attainment value. Consider, for example, a child who thinks of herself as "smart" and defines a certain course, e.g., advanced math, as an intellectually challenging task that course "smart" students should take. In this case, the value of enrolling in such a course would be high because enrolling and doing well in it would affirm a critical component of her self-concept.

Intrinsic or interest value, the second component of task value, is the inherent enjoyment one gets from engaging in an activity. In line with the suggestions of theorists studying components of intrinsic motivation (e.g., Deci, 1975; Kruglanski, 1975; Lepper & Green, 1978), we hypothesize that the value of the task and related achievement behaviors will increase as the intrinsic value of the task goes up.

Tasks could also have value apart from any feelings of interest or enjoyment. For example, a high school student may want to be a veterinarian. In preparation for this career, she may enroll in advanced mathematics classes, while at the same time having little interest in math itself. In this case, the desirability of the goal and the instrumentality of mathematics in helping her achieve that goal outweighs the student's negative or neutral attitude. The value of math would be high because it is perceived as instrumental for reaching the student's career goal. Utility value is thus believed to be influenced by salient long range goals such as education, plans and career aspirations.

In sum, we are proposing that task value is a function of both perceived qualities of the task and the individual's needs, goals and self perceptions. Individual differences on these factors could be created by differential experiences with that or similar tasks (past successes or failures), by social stereotypes (e.g., math as a male domain), by differential information from parents, teachers or peers about the importance of or the difficulty involved in doing well. Intuitively, three clusters of variables seem to be particularly important mediators of the value students attach to math:

Sex-role identity. Specific tasks are identified as either consistent or inconsistent with one's sex-role identity. The extent to which a task is consistent with one's sex-role identity determines the value of that task and ultimately, whether the individual will engage in that task. Central to this line of argument is the assumption that sex-role identity and the sex-typing of particular achievement activities interact to influence task value. Sex-role identity would influence task value only to the extent that the task is subjectively sex-typed by the individual, which, in turn, would affect the value of the task only to the extent that sex-role identity is a critical and salient component of one's self concept. Given that mathematics and careers involving math

competency are commonly viewed as male achievement domains, students' sex-typing of mathematics and various careers and students' sex-role identity may be important sources of individual differences in math course selection.

Cost of success and failure. The value of a task to an individual is also affected by a set of variables which can be best conceptualized as the cost of success or failure. These variables include the amount of effort one will have to expend in order to be successful, the loss of time which could be used to engage in other valued activities and the psychological cost of failure to one's self concept.

Previous or anticipated affective experiences. Achievement activities elicit a wide range of emotional responses. Many students report that a bad experience with one teacher resulted in negative feelings toward future math courses. Thus, to understand the value of various achievement activities, it is important to consider variations in the affective experiences students have had with the achievement activities. Variations in these experiences can take two quite different forms: a) variations in objective events like one's history of success and failure in math and the responses or behaviors of major socializers and, b) variations created by psychological factors such as subjective evaluations of the meaning of objective events, causal attributions and individual differences in confidence or anxiety.

I would like to conclude by summarizing the relevance of this theoretical model for explaining sex differences in students' course selection in mathematics. The model is built on the assumption that it is not reality itself (i.e., past successes or failures) that determines children's expectancies, values and behavior, but rather the interpretation of this reality that is the important causal determinant. As mentioned earlier, this could, in part, account for the apparent paradox of girls having lower estimates of their math ability and lower math achievement expectancies than boys, even though they do just as well in math as boys do during their early school years. Each child's interpretation of his or her achievement outcomes and future goals are mediated by causal attributional patterns for success and failure, the input of socializers, perceptions of their own needs, values and role

identity as well as their perceptions of the characteristics of the task. Each of these factors play a role in determining the expectancy and value associated with a particular task, which in turn influence a whole range of achievement-related behaviors potentially associated with that task, such as choice of the activity, intensity of the effort expended and actual performance.

The model also assumes that the decision to take mathematics is made in the context of a variety of choices and is guided by core values such as achievement needs, competency needs, and sex-role values and by more utilitarian values such as the importance of math achievement for future goals. Thus, if a girl likes math but feels that the amount of effort it will take to do well is not worthwhile because it decreases the time she will have available for more preferred activities (i.e., activities more consistent with her personal values), then she will be less likely to continue taking math. If a girl stereotypes mathematics or careers involving competency in mathematics as masculine and not in line with her own sex-role values, then she will be less likely to value mathematics learning and less likely to continue her mathematical studies, especially if she does not expect to do well.

Many of the theoretical predictions presented in this paper have not been adequately examined. In conjunction with the other papers presented in this symposium, it is hoped that the theoretical framework described in this paper will guide and stimulate further research on the role of expectancies and task value and their mediators in influencing academic choice and achievement behaviors.

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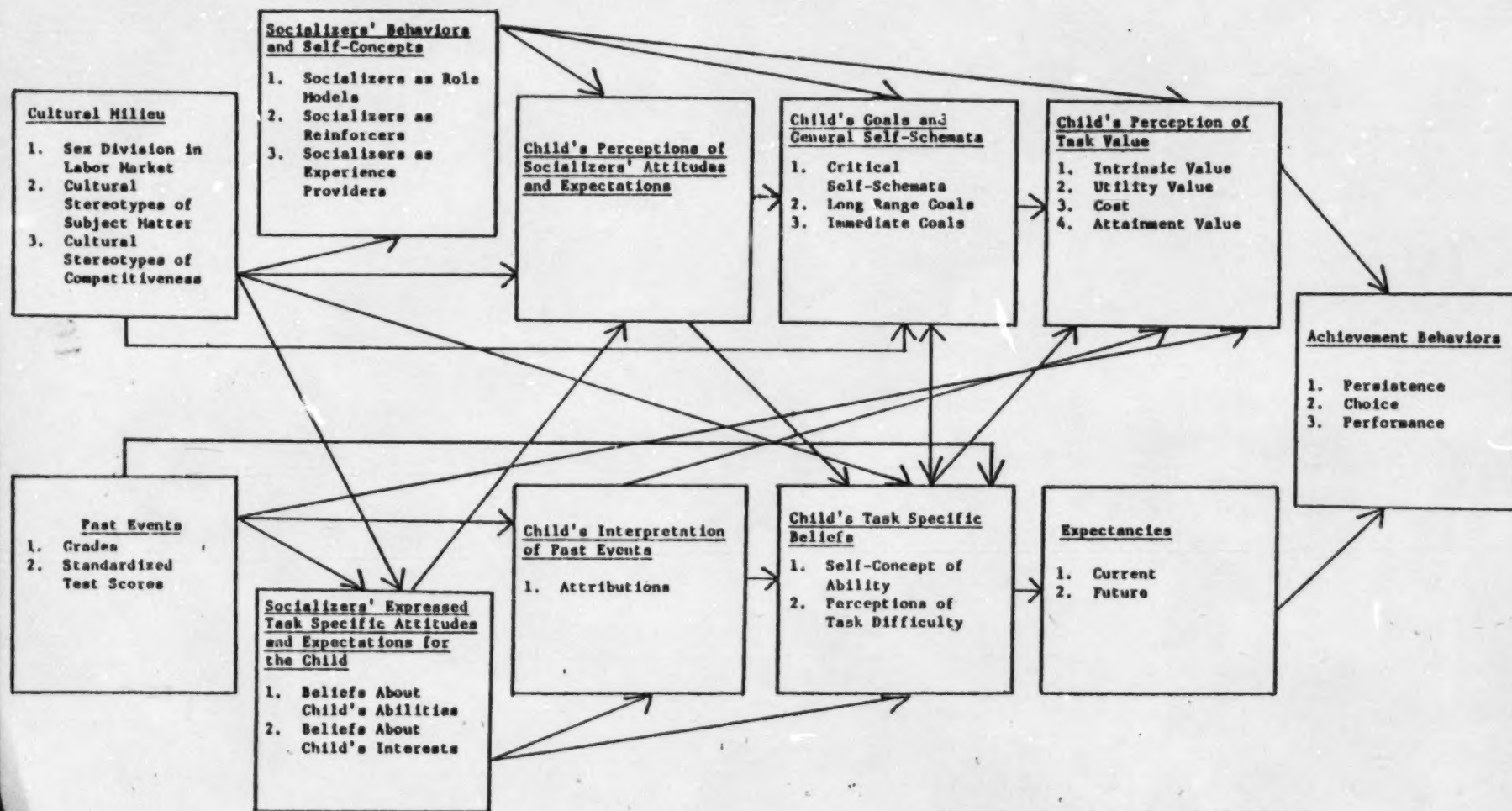


Figure 1. General Developmental Model of Achievement Behaviors.